

## CLAIMS LISTING

1. (currently amended) A method for optimizing a wireless electromagnetic communications network, comprising:

- a wireless electromagnetic communications network, comprising
  - a set of nodes, said set of nodes further comprising,
    - at least a first subset wherein each node is MIMO-capable, comprising:
      - an antennae array of  $M$   $M$  antennae, where  $M \geq 1$ ,
        - a transceiver for each antenna in said spatially diverse antennae array,
        - means for digital signal processing to convert analog radio signals into digital signals and digital signals into analog radio signals,
        - means for coding and decoding data, symbols, and control information into and from digital signals,
        - diversity capability means for transmission and reception of said analog radio ~~waves~~ signals,
        - and,
        - means for input and output from and to a non-radio interface for digital signals;
  - said set of nodes being deployed according to design rules that prefer meeting the following criteria:
    - said set of nodes further comprising two or more proper subsets of nodes, with a first proper subset being the transmit uplink / receive downlink set, and a second proper subset being the transmit downlink / receive uplink set;
    - each node in said set of nodes belonging to no more transmitting uplink or receiving uplink subsets than it has diversity capability means;

each node in a transmit uplink / receive downlink subset has no more nodes with which it will hold time and frequency coincident communications in its field of view, than it has diversity capability means;

each node in a transmit downlink / receive uplink subset has no more nodes with which it will hold time and frequency coincident communications in its field of view, than it has diversity capability means;

each member of a transmit uplink / receive downlink subset cannot hold time and frequency coincident communications with any other member of that transmit uplink / receive downlink subset;

and,

each member of a transmit downlink / receive uplink subset cannot hold time and frequency coincident communications with any other member of that transmit downlink / receive uplink subset;

transmitting, in said wireless electromagnetic communications network, independent information from each node belonging to a first proper subset, to one or more receiving nodes belonging to a second proper subset that are viewable from the transmitting node;

processing independently, in said wireless electromagnetic communications network, at each receiving node belonging to said second proper subset, information transmitted from one or more nodes belonging to said first proper subset;

and,

dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network.

2. (currently amended) A method for optimizing a wireless electromagnetic communications network, comprising:
- a wireless electromagnetic communications network, comprising

a set of nodes, said set of nodes further comprising,  
 at least a first subset wherein each node is MIMO-capable,  
 comprising:  
 a spatially diverse antennae array of  $M$   $M$  antennae, where  
 $M$   $M$   $\geq$  two,  
 a transceiver for each antenna in said spatially diverse  
 antennae array,  
 means for digital signal processing to convert analog radio  
 signals into digital signals and digital signals into analog  
 radio signals,  
 means for coding and decoding data, symbols, and control  
 information into and from digital signals,  
 diversity capability means for transmission and reception of  
 said analog radio ~~waves~~ signals,  
 and,  
 means for input and output from and to a non-radio  
 interface for digital signals;  
 said set of nodes being deployed according to design rules that prefer  
 meeting the following criteria:  
 said set of nodes further comprising two or more proper subsets of  
 nodes, with a first proper subset being the transmit uplink / receive  
 downlink set, and a second proper subset being the transmit  
 downlink / receive uplink set;  
 each node in said set of nodes belonging to no more transmitting  
 uplink or receiving uplink subsets than it has diversity capability  
 means;  
 each node in a transmit uplink / receive downlink subset has no  
 more nodes with which it will hold time and frequency coincident  
 communications in its field of view, than it has diversity capability  
means;

each node in a transmit downlink / receive uplink subset has no more nodes with which it will hold time and frequency coincident communications in its field of view, than it has diversity capability means;

each member of a transmit uplink / receive downlink subset cannot hold time and frequency coincident communications with any other member of that transmit uplink / receive downlink subset;

and,

each member of a transmit downlink / receive uplink subset cannot hold time and frequency coincident communications with any other member of that transmit downlink / receive uplink subset;

transmitting, in said wireless electromagnetic communications network, independent information from each node belonging to a first proper subset, to one or more receiving nodes belonging to a second proper subset that are viewable from the transmitting node;

processing independently, in said wireless electromagnetic communications network, at each receiving node belonging to said second proper subset, information transmitted from one or more nodes belonging to said first proper subset;

and,

dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network.

3. (currently amended) A method as in claim 1, wherein dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

using substantive null steering to minimize SINR between nodes transmitting and receiving information.

123 4. (currently amended) A method as in claim 1, wherein dynamically adapting the  
124 diversity ~~channels~~ capability means and said proper subsets to optimize said network  
125 further comprises:  
126 using max-SINR null- and beam-steering to minimize intra-network interference.  
127  
128  
129 5. (currently amended) A method as in claim 1, wherein dynamically adapting the  
130 diversity ~~channels~~ capability means and said proper subsets to optimize said network  
131 further comprises:  
132 using MMSE null- and beam-steering to minimize intra-network interference.  
133  
134  
135 6. (currently amended) A method as in claim 1, wherein dynamically adapting the  
136 diversity ~~channels~~ capability means and said proper subsets to optimize said network  
137 further comprises:  
138  
139 designing the network such that reciprocal symmetry exists for each pairing of  
140 uplink receive and downlink receive proper subsets.  
141  
142 7. (currently amended) A method as in claim 1, wherein dynamically adapting the  
143 diversity ~~channels~~ capability means and said proper subsets to optimize said network  
144 further comprises:  
145  
146 designing the network such that substantial reciprocal symmetry exists for each  
147 pairing of uplink receive and downlink receive proper subsets.  
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149 8. (original) A method as in claim 1, wherein the network uses TDD communication  
150 protocols.  
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152 9. (original) A method as in claim 1, wherein the network uses FDD communication  
153 protocols.

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155 10. (original) A method as in claim 3, wherein the network uses simplex communication  
156 protocols.

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158 11. (original) A method as in claim 1, wherein the network uses random access packets,  
159 and receive and transmit operations are all carried out on the same frequency channels for  
160 each link.

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162 12. (currently amended) A method as in claim 1, wherein dynamically adapting the  
163 diversity ~~channels~~ capability means and said proper subsets to optimize said network  
164 further comprises

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166 if the received interference is spatially white in both link directions, setting

167  ~~$g_1(q) \propto w_2^*(q)$  and  $g_2(q) \propto w_1^*(q)$~~

168  $g_2(q) \propto w_2^*(q)$  and  $g_1(q) \propto w_1^*(q)$  at both ends of the link,

169 where  ~~$\{g_2(q), w_1(q)\}$~~

170  $\{g_2(q), w_1(q)\}$  are the linear transmit and receive weights used in the  
171 downlink;

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173 but if the received interference is not spatially white in both link directions,

174 constraining  ~~$\{g_1(q)\}$  and  $\{g_2(q)\}$~~   $\{g_1(q)\}$  and  $\{g_2(q)\}$  to  
175 preferentially satisfy:

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177  ~~$Q_{21} \dots N_1$~~

178  ~~$\sum_{q=1}^{N_1} g_1^T(q) R_{1,1}(n) g_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{R_{1,1}(n)\} = M_1 R_1$~~

179  ~~$q=1 \dots n=1$~~

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$$\sum_{q=1}^{Q_{i_2}} \mathbf{g}_2^T(q) \mathbf{R}_{i_2 i_2} [n_2(q)] \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{i_2 i_2}(n)\} = M_2 R_2$$

$$\sum_{q=1}^{Q_{i_1}} \mathbf{g}_1^T(q) \mathbf{R}_{i_1 i_1} (n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{i_1 i_1}(n)\} = M_1 R_1$$

$$\sum_{q=1}^{Q_{i_2}} \mathbf{g}_2^T(q) \mathbf{R}_{i_2 i_2} (n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{i_2 i_2}(n)\} = M_2 R_2$$

13. (currently amended) A method as in claim 1, wherein:  
a proper subset may incorporate one or more nodes that are in a receive-only mode for every diversity ~~channel~~ capability means.

14. (original) A method as in claim 1, wherein:  
the network may dynamically reassign a node from one proper subset to another.

15. (original) A method as in claim 1, wherein:  
the network may dynamically reassign a proper subset of nodes from one proper subset to another.

16. (currently amended) A method as in claim 7, wherein the step of designing the network such that substantial reciprocal symmetry exists for the uplink and downlink channels further comprises:

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if the received interference is spatially white in both link directions, setting

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$$\mathbf{g}_1(q) \propto \mathbf{w}_2^*(q) \text{ and } \mathbf{g}_2(q) \propto \mathbf{w}_1^*(q)$$

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$$\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q) \text{ and } \mathbf{g}_1(q) \propto \mathbf{w}_1^*(q) \text{ at both ends of the link, where}$$

212

$$\{\mathbf{g}_2(q), \mathbf{w}_1(q)\} \quad \{\mathbf{g}_2(q), \mathbf{w}_1(q)\} \text{ are the linear transmit and}$$

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receive weights used in the downlink;

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but if the received interference is not spatially white in both link directions,

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$$\text{constraining } \{\mathbf{g}_1(q)\} \text{ and } \{\mathbf{g}_2(q)\} \quad \{\mathbf{g}_1(q)\} \text{ and } \{\mathbf{g}_2(q)\} \text{ to}$$

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preferentially satisfy:

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$$Q_{21} \text{ } \text{ } N_1$$

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$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{i_1 i_1} [n_1(q)] \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{i_1 i_1}(n)\} = M_1 R_1$$

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$$q=1 \text{ } \text{ } n=1$$

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$$Q_{12} \text{ } \text{ } N_2$$

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$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{i_2 i_2} [n_2(q)] \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{i_2 i_2}(n)\} =$$

225

$$M_2 R_2.$$

226

$$q=1 \text{ } \text{ } n=1$$

227

228

$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{i_1 i_1} (n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{i_1 i_1}(n)\} = M_1 R_1$$


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$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2$$


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233 17. (original) A method as in claim 1, wherein the means for digital signal processing in  
 234 said first subset of MIMO-capable nodes further comprises:

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236 an ADC bank for downconversion of received RF signals into digital signals;

237 a MT DEMOD element for multitone demodulation, separating the received

238 signal into distinct tones and splitting them into 1 through  $K$   $K_{\text{feed}}$  FDMA

239 channels, said separated tones in aggregate forming the entire baseband for the

240 transmission, said MT DEMOD element further comprising

241 a Comb element with a multiple of 2 filter capable of operating on a 128-

242 bit sample; and,

243 an FFT element with a 1,024 real-IF function;

244 a Mapping element for mapping the demodulated multitone signals into a 426

245 active receive bins, wherein

246 each bin covers a bandwidth of 5.75MHz;

247 each bin has an inner passband of 4.26MHz for a content envelope;

248 each bin has an external buffer, up and down, of 745kHz;

249 each bin has 13 channels, CH0 through CH12, each channel having 320

250 kHz and 32 tones, T0 through T31, each tone being 10kHz, with the inner

251 30 tones being used information bearing and T0 and T31 being reserved;

252 each signal being 100μs, with 12.5μs at each end thereof at the front and

253 rear end thereof forming respectively a cyclic prefix and cyclic suffix

254 buffer to punctuate successive signals;

255 and,

256 a symbol-decoding element for interpretation of the symbols embedded in the

257 signal.

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18. (currently amended) A method as in claim 1, wherein dynamically adapting the diversity channels capability means and said proper subsets to optimize said network further comprises

using at each node the receive combiner weights as transmit distribution weights during subsequent transmission operations, so that the network is preferentially designed and constrained such that each link is substantially reciprocal, such that the ad hoc network capacity measure can be made equal in both link directions by setting at both ends of the link:

$$\cancel{g_2(q) \propto w_2^*(k,q)} \text{ and } \cancel{g_1(k,q) \propto w_1^*(k,q)}$$

$$\underline{g_2(k,q) \propto w_2^*(k,q) \text{ and } g_1(k,q) \propto w_1^*(k,q) ,}$$

where  $\cancel{\{g_2(k,q), w_1(k,q)\}}$   $\{g_2(k,q), w_1(k,q)\}$  are the linear transmit and receive weights to transmit data  $d_2(k,q)$  from node  $n_2(q)$  to node  $n_1(q)$  over channel  $k$  in the downlink, and where  $\{g_1(k,q), w_2(k,q)\}$  are the linear transmit and receive weights used to transmit data  $d_1(k,q)$  from node  $n_1(q)$  back to node  $n_2(q)$  over equivalent channel  $k$  in the uplink.

19. (currently amended) A method as in claim 1, wherein the step of each node in a transmit downlink / receive uplink subset having no more nodes with which it will hold

time and frequency coincident communications in its field of view, than it has diversity capability means further comprises:

designing the topological, physical layout of nodes to enforce this constraint within the node's diversity ~~channels~~ capability means limitations.

20. (currently amended) A method as in claim 1, wherein the step of each node in a transmit uplink / receive downlink subset having no more nodes with which it will hold time and frequency coincident communications in its field of view, than it has diversity capability means further comprises:

designing the topological, physical layout of nodes to enforce this constraint within the node's diversity ~~channels~~ capability means limitations.

21. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

allowing a proper subset to send redundant data transmissions over multiple frequency channels to another proper subset.

22. (original) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

allowing a proper subset to send redundant data transmissions over multiple simultaneous or differential time slots to another proper subset.

314 23. (original) A method as in claim 1, wherein said transmitting proper subset and  
315 receiving proper subset diversity capability means for transmission and reception of said  
316 analog radio ~~waves~~ signals further comprise:

317       spatial diversity of antennae.

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320 24. (original) A method as in claim 1, wherein said transmitting proper subset and  
321 receiving proper subset diversity capability means for transmission and reception of said  
322 analog radio ~~waves~~ signals further comprise:

323       polarization diversity of antennae.

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326 25. (original) A method as in claim 1, wherein said transmitting proper subset and  
327 receiving proper subset diversity capability means for transmission and reception of said  
328 analog radio ~~waves~~ signals further comprise:

329       any combination of temporal, spatial, and polarization diversity of antennae.

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332 26. (currently amended)       A method as in claim 1, wherein the step of dynamically  
333 adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said  
334 network further comprises:

335       incorporating network control and feedback aspects as part of the signal encoding  
336       process.

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339 27. (currently amended)       A method as in claim 1, wherein the step of dynamically  
340 adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said  
341 network further comprises:

342       incorporating network control and feedback aspects as part of the signal encoding  
343       process and including said as network information in one direction of the  
344       signalling and optimization process, using the perceived environmental

condition's effect upon the signals in the other direction of the signalling and optimization process.

28. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

adjusting the diversity ~~channel~~ capability means use between any proper sets of nodes by rerouting any active link based on perceived unacceptable SINR experienced on that active link and the existence of an alternative available link using said adjusted diversity ~~channel~~ capability means.

29. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

switching a particular node from one proper subset to another due to changes in the external environment affecting links between that node and other nodes in the network.

30. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

dynamically reshuffling proper subsets to more closely attain network objectives by taking advantage of diversity ~~channels~~ capability means availability.

31. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

376 dynamically reshuffling proper subsets to more closely attain network objectives  
377 by accounting for node changes.  
378  
379  
380 32. (currently amended) A method as in claim 31, wherein said node changes  
381 include any of:  
382 adding diversity capability means to a node, adding a new node within the field of  
383 view of another node, removing a node from the network (temporarily or  
384 permanently), or losing diversity capability means at a node.  
385  
386  
387 33. (currently amended) A method as in claim 1, wherein the step of dynamically  
388 adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said  
389 network further comprises:  
390 suppressing unintended recipients or transmitters by the imposition of signal  
391 masking.  
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393  
394 34. (original) A method as in claim 33, wherein the step of suppressing unintended  
395 recipients or transmitters by the imposition of signal masking further comprises:  
396 imposition of an origination mask.  
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399 34. (original) A method as in claim 33, wherein the step of suppressing unintended  
400 recipients or transmitters by the imposition of signal masking further comprises:  
401 imposition of a recipient mask.  
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404 35. (original) A method as in claim 33, wherein the step of suppressing unintended  
405 recipients or transmitters by the imposition of signal masking further comprises:  
406 imposition of any combination of origination and recipient masks.

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409 36. (currently amended) A method as in claim 33, wherein the step of dynamically  
410 adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said  
411 network further comprises:

412 using signal masking to secure transmissions against unintentional, interim  
413 interception and decryption by the imposition of a signal mask at origination, the  
414 transmission through any number of intermediate nodes lacking said signal mask,  
415 and the reception at the desired recipient which possesses the correct means for  
416 removal of the signal mask.

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419 37. (original) A method as in claim 36, wherein the signal masking is shared by a proper  
420 subset.

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423 38. (currently amended) A method as in claim 1, wherein the step of dynamically  
424 adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said  
425 network further comprises:

426 heterogenous combination of a hierarchy of proper subsets, one within the other,  
427 each paired with a separable subset wherein the first is a transmit uplink and the  
428 second is a transmit downlink subset, such that the first subset of each pair of  
429 subsets is capable of communication with the members of the second subset of  
430 each pair, yet neither subset may communicate between its own members.

431

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433 39. (original) A method as in claim 1, wherein the step of dynamically adapting the  
434 diversity ~~channels~~ capability means and said proper subsets to optimize said network  
435 further comprises:

using as many of the available diversity ~~channels~~ capability means as are needed for traffic between any two nodes from 1 to NumChannels, where NumChannels equals the maximal diversity capability means between said two nodes.

40. (original) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

~~using~~ using a water-filling algorithm to route traffic between an origination and destination node through any intermediate subset of nodes that has available diversity ~~channel~~ capability means capacity.

41. (currently amended) A method for optimizing a wireless electromagnetic communications network, comprising:

a wireless electromagnetic communications network, comprising

a set of nodes, said set further comprising,

at least a first subset of MIMO-capable nodes, each MIMO-capable node comprising:

a spatially diverse antennae array of ~~M~~ M antennae, where ~~M~~ M  $\geq$  two, said antennae array being polarization diverse, and circularly symmetric, and providing 1-to-M RF feeds; a transceiver for each antenna in said array, said transceiver further comprising

a Butler Mode Forming element, providing spatial signature separation with a FFT-LS algorithm, reciprocally forming a transmission with shared receiver feeds, such that the number of modes out equals the numbers of antennae, establishing such as an ordered set with decreasing energy, further comprising:



466 a dual-polarization element for splitting the  
 467 modes into positive and negative polarities  
 468 with opposite and orthogonal polarizations,  
 469 that can work with circular polarizations,  
 470 and  
 471 a dual-polarized link CODEC;  
 472 a transmission/reception switch comprising,  
 473 a vector OFDM receiver element;  
 474 a vector OFDM transmitter element;  
 475 a LNA bank for a receive signal, said LNA  
 476 Bank also instantiating low noise  
 477 characteristics for a transmit signal;  
 478 a PA bank for the transmit signal that  
 479 receives the low noise characteristics for  
 480 said transmit signal from said LNA bank;  
 481 an AGC for said LNA bank and PA bank;  
 482 a controller element for said  
 483 transmission/reception switch enabling  
 484 baseband link distribution of the energy over  
 485 the multiple RF feeds on each channel to  
 486 steer up to  $K$   $K_{\text{feed}}$  beams and nulls  
 487 independently on each FDMA channel;  
 488 a Frequency Translator;  
 489 a timing synchronization element controlling  
 490 said controller element;  
 491 further comprising a system clock,  
 492 a universal Time signal element;  
 493 GPS;  
 494 a multimode power management element  
 495 and algorithm;  
 496 and,

497 a LOs element;  
 498 said vector OFDMreceiver element comprising  
 499 an ADC bank for downconversion of  
 500 received RF signals into digital signals;  
 501 a MT DEMOD element for multitone  
 502 demodulation, separating the received signal  
 503 into distinct tones and splitting them into 1  
 504 through  $K - K_{\text{feed}}$  FDMA channels, said  
 505 separated tones in aggregate forming the  
 506 entire baseband for the transmission, said  
 507 MT DEMOD element further comprising  
 508 a Comb element with a multiple of 2  
 509 filter capable of operating on a 128-  
 510 bit sample; and,  
 511 an FFT element with a 1,024 real-IF  
 512 function;  
 513 a Mapping element for mapping the  
 514 demodulated multitone signals into a 426  
 515 active receive bins, wherein  
 516 each bin covers a bandwidth of  
 517 ~~5.75MHz~~ 5.75 MHz;  
 518 each bin has an inner passband of  
 519 ~~4.26MHz~~ 4.26 MHz for a content  
 520 envelope;  
 521 each bin has an external buffer, up  
 522 and down, of ~~745kHz~~ 745 kHz;  
 523 each bin has 13 channels, CH0  
 524 through CH12, each channel having  
 525 320 kHz and 32 tones, T0 through  
 526 T31, each tone being ~~10kHz~~ 10 kHz,  
 527 with the inner 30 tones being used

528 information bearing and T0 and T31  
 529 being reserved;  
 530 each signal being ~~100 $\mu$ s~~ 100  $\mu$ s, with  
 531 ~~12.5 $\mu$ s~~ 12.5  $\mu$ s at each end thereof at  
 532 the front and rear end thereof  
 533 forming respectively a cyclic prefix  
 534 and cyclic suffix buffer to punctuate  
 535 successive signals;  
 536 a MUX element for timing modification  
 537 capable of element-wise multiplication  
 538 across the signal, which halves the number  
 539 of bins and tones but repeats the signal for  
 540 high-quality needs;  
 541 a link CODEC, which separates each FDMA  
 542 channel into 1 through M M links, further  
 543 comprising  
 544 a SOVA bit recovery element;  
 545 an error coding element;  
 546 an error detection element;  
 547 an ITI remove element;  
 548 a tone equalization element;  
 549 and,  
 550 a package fragment retransmission  
 551 element;  
 552 a multilink diversity combining element,  
 553 using a multilink Rx weight adaptation  
 554 algorithm for Rx signal weights ~~W(k)~~  
 555 W(k) to adapt transmission gains  
 556 ~~G(k)~~ G(k) for each channel ~~k~~ k;

557 an equalization algorithm, taking the signal  
 558 from said multilink diversity combining  
 559 element and controlling a delay removal  
 560 element;  
 561 said delay removal element separating signal  
 562 content from imposed pseudodelay and  
 563 experienced environmental signal delay, and  
 564 passing the content-bearing signal to a  
 565 symbol-decoding element;  
 566 said symbol-decoding element for  
 567 interpretation of the symbols embedded in  
 568 the signal, further comprising:  
 569 an element for delay gating;  
 570 a QAM element; and  
 571 a PSK element;  
 572 said vector OFDM transmitter element comprising:  
 573 a DAC bank for conversion of digital signals  
 574 into RF signals for transmission;  
 575 a MT MOD element for multitone  
 576 modulation, combining and joining the  
 577 signal to be transmitted from 1 through  $K$   
 578  $K_{\text{feed}}$  FDMA channels, said separated tones  
 579 in aggregate forming the entire baseband for  
 580 the transmission, said MT MOD element  
 581 further comprising  
 582 a Comb element with a multiple of 2  
 583 filter capable of operating on a 128-  
 584 bit sample; and,  
 585 an IFFT element with a 1,024 real-IF  
 586 function;

587 a Mapping element for mapping the  
 588 modulated multitone signals from 426  
 589 active transmit bins, wherein  
 590 each bin covers a bandwidth of  
 591 ~~5.75MHz~~ 5.75 MHz;  
 592 each bin has an inner passband of  
 593 ~~4.26MHz~~ 4.26 MHz for a content  
 594 envelope;  
 595 each bin has an external buffer, up  
 596 and down, of ~~745kHz~~ 745 kHz;  
 597 each bin has 13 channels, CH0  
 598 through CH12, each channel having  
 599 320 kHz and 32 tones, T0 through  
 600 T31, each tone being ~~10kHz~~ 10 kHz,  
 601 with the inner 30 tones being used  
 602 information bearing and T0 and T31  
 603 being reserved;  
 604 each signal being ~~100μs~~ 100 μs, with  
 605 ~~12.5μs~~ 12.5 μs at each end thereof at  
 606 the front and rear end thereof  
 607 forming respectively a cyclic prefix  
 608 and cyclic suffix buffer to punctuate  
 609 successive signals;  
 610 a MUX element for timing modification  
 611 capable of element-wise multiplication  
 612 across the signal, which halves the number  
 613 of bins and tones but repeats the signal for  
 614 high-quality needs;  
 615 a symbol-coding element for embedding the  
 616 symbols to be interpreted by the receiver in  
 617 the signal, further comprising:

618 an element for delay gating;  
 619 a QAM element; and  
 620 a PSK element;  
 621 a link CODEC, which aggregates each  
 622 FDMA channel from 1 through  $M$   $M$  links,  
 623 further comprising  
 624 a SOVA bit recovery element;  
 625 an error coding element;  
 626 an error detection element;  
 627 an ITI remove element;  
 628 a tone equalization element;  
 629 and,  
 630 a package fragment retransmission  
 631 element;  
 632 a multilink diversity distribution element,  
 633 using a multilink Tx weight adaptation  
 634 algorithm for Tx signal weights to adapt  
 635 transmission gains  $\underline{G(k)}$   $G(k)$  for each  
 636 channel  ~~$k$~~   $k$ , such that  ~~$g(q;k) \propto$~~   
 637  ~~$w^*(q;k)$~~   $g(q;k) \propto w^*(q;k)$  ;  
 638 a TCM codec;  
 639 a pilot symbol CODEC element that integrates with said  
 640 FFT-LS algorithm a link separation, a pilot and data signal  
 641 elements sorting, a link detection, multilink combination,  
 642 and equalizer weight calculation operations;  
 643 means for diversity transmission and reception,  
 644 and,  
 645 means for input and output from and to a non-radio  
 646 interface;

647  
648 said set of nodes being deployed according to design rules that prefer  
649 meeting the following criteria:

650 said set of nodes further comprising two or more proper subsets of  
651 nodes, with a first proper subset being the transmit uplink / receive  
652 downlink set, and a second proper subset being the transmit  
653 downlink / receive uplink set;

654  
655 each node in said set of nodes belonging to no more transmitting  
656 uplink or receiving uplink subsets than it has diversity capability  
657 means;

658  
659 each node in a transmit uplink / receive downlink subset has no  
660 more nodes with which it will hold time and frequency coincident  
661 communications in its field of view, than it has diversity capability  
662 means;

663  
664 each node in a transmit downlink / receive uplink subset has no  
665 more nodes with which it will hold time and frequency coincident  
666 communications in its field of view, than it has diversity capability  
667 means;

668  
669 each member of a transmit uplink / receive downlink subset cannot  
670 hold time and frequency coincident communications with any  
671 other member of that transmit uplink / receive downlink subset;

672  
673 and,

674  
675 each member of a transmit downlink / receive uplink subset cannot  
676 hold time and frequency coincident communications with any  
677 other member of that transmit downlink / receive uplink subset;

transmitting, in said wireless electromagnetic communications network, independent information from each node belonging to a first proper subset, to one or more receiving nodes belonging to a second proper subset that are viewable from the transmitting node;

processing independently, in said wireless electromagnetic communications network, at each receiving node belonging to said second proper subset, information transmitted from one or more nodes belonging to said first proper subset;

and,

designing the network such that substantially reciprocal symmetry exists for the uplink and downlink channels by,

if the received interference is spatially white in both link directions, setting

$$\mathbf{g}_1(q) \propto \mathbf{w}_2^*(q) \text{ and } \mathbf{g}_2(q) \propto \mathbf{w}_1^*(q)$$

$$\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q) \text{ and } \mathbf{g}_1(q) \propto \mathbf{w}_1^*(q) \text{ at both ends of the link,}$$

where  $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$  and  $\{\mathbf{g}_1(q), \mathbf{w}_2(q)\}$  are the linear transmit and receive weights used in the downlink;

but if the received interference is not spatially white in both link directions, constraining  $\{\mathbf{g}_1(q)\}$  and  $\{\mathbf{g}_2(q)\}$

$\{\mathbf{g}_1(q)\}$  and  $\{\mathbf{g}_2(q)\}$  to satisfy:

$Q_{2+}$

$$\sum \mathbf{g}_1^T(q) \mathbf{R}_{i+1+1}[\mathbf{n}_1(q)] \mathbf{g}_1^*(q) =$$



$$\begin{aligned} & \sum_{q=1}^{Q_{12}} \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{i_1 i_1}(n)\} = M_1 R_1 \end{aligned}$$

$$\begin{aligned} & \sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{i_2 i_2} [n_2(q)] \mathbf{g}_2^*(q) = \\ & \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{i_2 i_2}(n)\} = M_2 R_2, \end{aligned}$$

$$\sum_{q=1}^{Q_{12}} \mathbf{g}_1^T(q) \mathbf{R}_{i_1 i_1} (n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{i_1 i_1}(n)\} = M_1 R_1$$

$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{i_2 i_2} (n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{i_2 i_2}(n)\} = M_2 R_2;$$

using any standard communications protocol, including TDD, FDD, simplex,

and,

optimizing the network by dynamically adapting the diversity channels capability means between nodes of said transmitting and receiving subsets.

730

731

732 42. (original) A method as in claim 41, wherein said a transmission/reception switch  
733 further comprises:

734

735 an element for tone and slot interleaving.

736

737 43. (original) A method as in claim 41, wherein said TMC codec and SOVA decoder are  
738 replaced with a Turbo codec.

739

740 44. (currently amended) A method as in claim 1, wherein the step of  
741 dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to  
742 optimize said network further comprises:

743 optimizing at each node acting as a receiver the receive weights using ~~the a~~  
744 MMSE technique to adjust the multitone transmissions between it and other  
745 nodes.

746

747

748 45. (currently amended) A method as in claim 1, wherein the step of dynamically  
749 adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said  
750 network further comprises:

751 optimizing at each node acting as a receiver the receive weights using the ~~MAX~~  
752 maximum SINR to adjust the multitone transmissions between it and other nodes.

753

754

755 46. (currently amended) A method as in claim 1, wherein the step of dynamically  
756 adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said  
757 network further comprises:

758 optimizing at each node acting as a receiver the receive weights, then optimizing  
759 the transmit weights at that node by making them proportional to the receive

weights, and then optimizing the transmit gains for that node by a max-min criterion for the link capacities for that node at that particular time.

47. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

including, as part of said network, one or more network controller elements that assist in tuning local node's maximum ~~capacity~~ capacity criteria and link channel diversity usage to network constraints.

48. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

characterizing the channel response vector  $\mathbf{a}_1(f, t; n_2, n_1)$  by the observed (possibly time-varying) azimuth and elevation  $\{\theta_1(t; n_2, n_1), \varphi_1(f, t; n_2, n_1)\}$  of node  $n_2$  observed at  $n_1$ .

49. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

characterizing the channel response vector  $\mathbf{a}_1(f, t; n_2, n_1)$  as a superposition of direct-path and near-field reflection path channel responses, e.g., due to scatterers in the vicinity of  $n_1$ , such that each element of  $\mathbf{a}_1(f, t; n_2, n_1)$  can be modeled as a random process, possibly varying over time and frequency.

50. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity channels capability means and said proper subsets to optimize said network further comprises:

presuming that  $\mathbf{a}_1(f, t; n_2, n_1)$  and  $\mathbf{a}_1(f, t; n_{2[1]}, n_{4[2]})$  can be substantively time invariant over significant time durations, e.g., large numbers of OFDM symbols or TDMA time frames, and inducing the most significant frequency and time variation by the observed timing and carrier offset on each link.

51. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity channels capability means and said proper subsets to optimize said network further comprises:

in such networks, e.g., TDD networks, wherein the transmit and receive frequencies are identical ( $f_{21}(k) = f_{12}(k) = f(k)$ ) and the transmit and receive time slots are separated by short time intervals ( $t_{21}(l) = t_{12}(l) + \Delta_{21} \approx t(l)$ ), and  $\mathbf{H}_{21}(k, l)$  and  $\mathbf{H}_{12}(k, l)$  become substantively reciprocal, such that the subarrays comprising  $\mathbf{H}_{21}(k, l)$  and  $\mathbf{H}_{12}(k, l)$  satisfy

$$\mathbf{H}_{21}(k, l; n_2, n_1) \approx \delta_{21}(k, l; n_1, n_2) \mathbf{H}_{12}^T(k, l; n_1, n_2),$$

where  $\delta_{21}(k, l; n_1, n_2)$  is a unit-magnitude, generally nonreciprocal scalar, equalizing the observed timing offsets, carrier offsets, and phase offsets, such that  $\lambda_{21}(n_2, n_1) \approx \lambda_{12}(n_1, n_2)$ ,  $\tau_{21}(n_2, n_1) \approx \tau_{12}(n_{21}, n_{42})$ , and  $\nu_{21}(n_1, n_2) \approx \nu_{12}(n_{21}, n_{42})$ , by synchronizing each node to an external,

811 universal time and frequency standard, obtaining  $\delta_{21}(k, l; n_{4[2]}, n_{2[1]}) \approx$   
812 1, and establishing network channel response as truly reciprocal  $\mathbf{H}_{21}(k, l) \approx$   
813  $\mathbf{H}_{21}^T \mathbf{H}_{12}^T(k, l)$ .

814

815

816 52. A method as in claim 51, wherein the synchronization of each node is to Global  
817 Position System Universal Time Coordinates (GPS UTC).

818

819

820 53. (original) A method as in claim 51, wherein the synchronization of each node is to a  
821 network timing signal.

822

823

824 54. (original) A method as in claim 51, wherein the synchronization of each node is to a  
825 combination of Global Position System Universal Time Coordinates (GPS UTC) and a  
826 network timing signal.

827

828

829 55. (currently amended) A method as in claim 1, wherein the step of dynamically  
830 adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said  
831 network further comprises:

832 for such parts of the network where the internode channel responses possess  
833 substantive multipath, such that  $\mathbf{H}_{21}(k, l; n_2, n_1)$  and  $\mathbf{H}_{21 \underline{12}}(k, l$   
834  $; n_{2\underline{1}}, n_{1\underline{2}})$  have rank greater than unity, making the channel response  
835 substantively reciprocal by:

836

837 (1) forming uplink and downlink transmit signals using the matrix formula  
838 in EQ. 40

$$\mathbf{s}_1(k, l; n_1) = \mathbf{G}_1(k, l; n_1) \mathbf{d}_1(k, l; n_1)$$

$$\mathbf{s}_2(k, l; n_1) = \mathbf{G}_2(k, l; n_2) \mathbf{d}_2(k, l; n_2);$$

(2) reconstructing the data intended for each receive node using the matrix formula in EQ. 41

$$\mathbf{y}_1(k, l; n_1) = \mathbf{W}_1^H(k, l; n_1) \mathbf{x}_1(k, l; n_1)$$

$$\mathbf{y}_2(k, l; n_2) = \mathbf{W}_2^H(k, l; n_2) \mathbf{x}_2(k, l; n_2);$$

(3) developing combiner weights that  $\{\mathbf{w}_1(k, l; n_2, n_1)\}$  and  $\{\mathbf{w}_2(k, l; n_1, n_2)\}$  that substantively null data intended for recipients during the symbol recovery operation, such that for  $n_1 \neq n_2$ :

(4) developing distribution weights  $\{\mathbf{g}_1(k, l; n_2, n_1)\}$  and  $\{\mathbf{g}_2(k, l; n_1, n_2)\}$  that perform equivalent substantive nulling operations during transmit signal formation operations;

(5) scaling distribution weights to optimize network capacity and/or power criteria, as appropriate for the specific node topology and application addressed by the network;

(6) removing residual timing and carrier offset remaining after recovery of the intended network data symbols;

and

(7) encoding data onto symbol vectors based on the end-to-end SINR obtainable between each transmit and intended recipient node, and

859 decoding that data after symbol recovery operations, using channel coding  
 860 and decoding methods develop in prior art.

861

862 56. (currently amended) A method as in claim 1, wherein dynamically adapting the  
 863 diversity ~~channels~~ capability means and said proper subsets to optimize said network  
 864 further comprises:

865 forming substantively nulling combiner weights using an FFT-based least-squares  
 866 algorithms that adapt  $\{\mathbf{w}_1(k, l; n_2, n_1)\}$  and  $\{\mathbf{w}_2(k, l; n_1, n_2)\}$  to  
 867 values that minimize the mean-square error (MSE) between the combiner output  
 868 data and a known segment of transmitted pilot data;

869 applying the pilot data to an entire OFDM symbol at the start of an adaptation  
 870 frame comprising a single OFDM symbol containing pilot data followed by a  
 871 stream of OFDM symbols containing information data;

872 wherein the pilot data transmitted over the pilot symbol is preferably given by  
 873 ~~EQ. 44 and EQ. 45,~~

$$874 \quad p_1(k; n_2, n_1) = d_1(k, 1; n_2, n_1)$$

$$875 \quad = p_{01}(k) p_{21}(k; n_2) p_{11}(k; n_1)$$

$$876 \quad p_2(k; n_1, n_2) = d_2(k, 1; n_1, n_2)$$

$$877 \quad = p_{02}(k) p_{12}(k; n_1) p_{22}(k; n_2)$$

878 such that the “pseudodelays”  $\delta_1(n_1)$  and  $\delta_2(n_2)$  are unique to each transmit  
 879 node (in small networks), or provisioned at the beginning of communication with

880 any given recipient node (in which case each will be a function of  $n_1$  and  $n_2$ ),  
 881 giving each pilot symbol a pseudorandom component;  
 882 maintaining minimum spacing between any pseudodelays used to communicate  
 883 with a given recipient node that is larger than the maximum expected timing  
 884 offset observed at that recipient node, said spacing should also being an integer  
 885 multiple of  $1/K$ , where  $K$  is the number of tones used in a single FFT-based LS  
 886 algorithm;  
 887 and if  $K$  is not large enough to provide a sufficiency of pseudodelays, using  
 888 additional OFDM symbols for transmission of pilot symbols, either lengthening  
 889 the effective value of  $K$ , or reducing the maximum number of originating nodes  
 890 transmitting pilot symbols over the same OFDM symbol;  
 891 also providing  $K$  large enough to allow effective combiner weights to be  
 892 constructed from the pilot symbols alone;  
 893 then obtaining the remaining information-bearing symbols, which are the uplink  
 894 and downlink data symbols provided by prior encoding, encryption, symbol  
 895 randomization, and channel preemphasis stages, in the adaptation frame, by using  
 896 EQ. 46 and EQ. 47

$$897 \quad d_1(k, l; n_2, n_1) = p_1(k; n_2, n_1) d_{01}(k, l; n_2, n_1)$$

$$898 \quad d_2(k, l; n_1, n_2) = p_2(k; n_1, n_2) d_{02}(k, l; n_1, n_2);$$

899 removing at the recipient node, first the pseudorandom pilot components from the  
 900 received data by multiplying each tone and symbol by the pseudorandom  
 901 components of the pilot signals, using EQ. 47 and EQ. 48



$$d_2(k, l; n_1, n_2) = p_2(k; n_1, n_2) d_{02}(k, l; n_1, n_2)$$

$$\mathbf{x}_{02}(k, l; n_2) = c_{01}(k; n_2) \mathbf{x}_2(k, l; n_2);$$

thereby transforming each authorized and intended pilot symbol for the recipient node into a complex sinusoid with a slope proportional to the sum of the pseudodelay used during the pilot generation procedure, and the actual observed timing offset for that link, and leaving other, unauthorized pilot symbols, and symbols intended for other nodes in the network, untransformed and so appearing as random noise at the recipient node.

910

911

912 57. (currently amended) A method as in claim 55, wherein the FFT-Least Squares  
913 algorithm is that shown in Figure 37, further comprises:

914 using a pilot symbol, which is multiplied by a unit-norm FFT window function;

915 passing that result to a QR decomposition algorithm and computing orthogonalized

916 data  $\{\mathbf{q}(k)\}$  and an upper-triangular Cholesky statistics matrix  $\mathbf{R}$ ;

917 then multiplying each vector element of  $\{\mathbf{q}(k)\}$  by the same unit-norm FFT

918 window function and passing it through a zero-padded inverse Fast Fourier

919 Transform (IFFT) with output length  $PK$ , with padding factor  $P$  to form

920 uninterpolated, spatially whitened processor weights  $\{\mathbf{u}(m)\}$ , where lag index

921  $m$  is proportional to target pseudodelay  $\delta(m) = m/PK$ ;

922 then using the spatially whitened processor weights to estimate the mean-square-  
923 error (MSE) obtaining for a signal received at each target pseudodelay,

924  $\varepsilon(m) = 1 - \|\mathbf{u}(m)\|^2$ , yielding a detection statistic (pseudodelay indicator

925 function), with an extreme at IFFT lags commensurate with the observed

pseudodelay and designed to minimize interlag interference between pilot signal  
 features in the pseudodelay indicator function;  
 using an extremes-finding algorithm to detect each extreme;  
 estimating the location of the observed pseudodelays to sub-lag accuracy;  
 determining additional ancillary statistics;  
 selecting the extremes beyond a designated MSE threshold;  
 interpolating spatially whitened weights  $\mathbf{U}$  from weights near the extremes;  
 using the whitened combiner weights  $\mathbf{U}$  to calculate both unwhitened combiner  
 weights  $\mathbf{W} = \mathbf{R}^{-1}\mathbf{U}$  to be used in subsequent data recovery operations, and to  
 estimate the received channel aperture matrix  $\mathbf{A} = \mathbf{R}^H\mathbf{U}$ , to facilitate ancillary  
 signal quality measurements and fast network entry in future adaptation frames;  
 and, lastly,  
 using an estimated and optimized pseudodelay vector  $\delta_*$  to generate  $\mathbf{c}_1(k) =$   
 $\exp\{-j2\pi\delta_*k\}$  (conjugate of  $\{p_{11}(k; n_1)\}$  during uplink receive  
 operations, and  $\{p_{22}(k; n_2)\}$  during downlink receive operations), which is then  
 used to remove the residual observed pseudodelay from the information bearing  
 symbols.

58. (original) A method as in claim 55, wherein the pseudodelay estimation is refined  
 using a Gauss-Newton recursion using the approximation :

$$\exp\{-j2\pi\Delta(k-k_0)/PK\} \approx 1 -j2\pi\Delta(k-k_0)/PK.$$

59. (currently amended) A method as in claim 1, wherein dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

using the linear combiner weights provided during receive operations are construct linear distribution weights during subsequent transmit operations, by setting distribution weight  $\mathbf{g}_1(k, l; n_2, n_1)$  proportional to  $\mathbf{w}_1^*(k, l; n_2, n_1)$  during uplink transmit operations, and  $\mathbf{g}_2(k, l; n_1, n_2)$  proportional to  $\mathbf{w}_2^*(k, l; n_1, n_2)$  during downlink transmit operations; thereby making the transmit weights substantively nulling and thereby allowing each node to form frequency and time coincident two-way links to every node in its field of view, with which it is authorized (through establishment of link set and transfer of network/recipient node information) to communicate.

60. (original) A method as in claim 1, wherein each node in the first subset of nodes further comprises:  
a LEGO implementation element and algorithm.

61. (currently amended) A method as in claim 1, wherein dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

balancing the power use against capacity for each channel, link, and node, and hence for the network as a whole by:

establishing a capacity objective  $\mathbf{B} \{ \underline{\beta(m)} \}$  for a ~~particular Node-2~~ user 2 node receiving from a user 1 node ~~another Node-1~~ as the target to be achieved by the user 2 node ~~node-2~~;

solving, at ~~the user 2 node~~ Node-2 the local optimization problem:

$$\min \sum_q \pi_1(q) = \underline{\mathbf{1}}^T \boldsymbol{\pi}_1, \text{ such that}$$

$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m),$$

where  $\pi_1(q)$  is the ~~SU (user-1-node)~~ transmit power for link number  ~~$q$~~   $q$  for the user 1 node,

$\gamma(q)$  is the signal to interference and noise ratio (SINR) seen at the output of the beamformer,

$\mathbf{1}$  is a vector of all 1s,

and,

$\boldsymbol{\pi}_1$  is a vector whose  ~~$q^{th}$ -element is  $\pi_1(q)$~~   $q^{th}$  element is  $\pi_1(q)$ ,

the aggregate set  ~~$Q(m)$~~   $Q(m)$  contains a set of links that are grouped together for the purpose of measuring capacity flows through those links;

using at ~~Node-2~~ the user 2 node the local optimization solution to moderate the transmit and receive weights, and signal information, returned to ~~node-1~~ user 1 node;

and,

using said feedback to compare against the capacity objective  $\mathcal{B}$   $\{\beta(m)\}$  and incrementally adjust the transmit power at each of ~~Node-1~~ the user 1 node and ~~Node-2~~ the user 2 node until no further improvement is perceptible.

62. (currently amended) A method as in claim 1, wherein dynamically adapting the diversity channels capability means and said proper subsets to optimize said network further comprises:

1004 using the downlink objective function in ~~EQ. 5 and EQ. 6~~

1005 
$$\min \sum_q \pi_2(q) = \mathbf{1}^T \boldsymbol{\pi}_2 \text{ such that } \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq$$

1006 
$$\beta(m)$$

1007 at each node to perform local optimization;

1008 reporting the required feasibility condition,  $\sum_{q \in Q(m)} \pi_1(q) \leq R_1(m)$

1009 
$$\underline{\sum_{q \in Q(m)} \pi_1(q) \leq R_1(m)} ;$$

1010 and,

1011 modifying  $\beta(m)$  as necessary to stay within the constraint.

1012

1013

1014 63. (original) A method as in claim ~~60~~ 61, wherein:

1015 the capacity constraints  $\beta(m)$  are determined in advance for each proper subset

1016 of nodes, based on known QoS requirements for each said proper subset.

1017

1018

1019 64. (currently amended) A method as in claim ~~60~~ 61, wherein said network further

1020 seeks to minimize total power in the network as suggested by ~~EQ. 4~~

1021 
$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m).$$

1022

1023

1024 65. (currently amended) A method as in claim ~~60~~ 61, wherein said network sets as a

1025 target objective for the network  $\underline{\mathbf{B} \{ \beta(m) \}}$  the QoS for the network.

1026

1027

66. (currently amended) A method as in claim 60 61, wherein said network sets as a target objective for the network  $\mathbf{B} \{ \beta(m) \}$  a vector of constraints.

67. (currently amended) A method as in claim 60 61, wherein the local optimization problem is further defined such that:

the receive and transmit weights are unit normalized with respect to the background interference autocorrelation matrix;

the local SINR is expressed as ~~EQ. 8~~

$$\gamma(q) = \frac{P_{rt}(q, q) \pi_t(q)}{1 + \sum_{j \neq q} P_{rt}(q, j) \pi_t(j)};$$

and the weight normalization ~~in EQ. 6~~

$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

is used to enable  $D_{12}(\mathbf{W}, \mathbf{G}) = D_{21}(\mathbf{G}^*, \mathbf{W}^*)$ , where  $(\mathbf{W}_2, \mathbf{G}_1)$  and  $(\mathbf{W}_1, \mathbf{G}_2)$  represent the receive and transmit weights employed by all nodes in the network during uplink and downlink operations, respectively, the ~~reciprocity equation~~ at that node, thereby allowing the uplink and downlink function to be presumed identical rather than separately computed.

68. (currently amended) A method as in claim 60 61, wherein:  
very weak constraints to the transmit powers are approximated by using a very simple approximation for  $\gamma(q)$   $\gamma(q)$ .

69. (currently amended) A method as in claim ~~60~~ 61, for the cases wherein all the aggregate sets contain a single link and non-negligible environmental noise is present, wherein the transmit powers are computed as Perron vectors from ~~EQ. 10~~,

$$\begin{aligned}
 D_{21} &= \log \left( 1 + \frac{1}{\rho(\mathbf{P}_{21}) - 1} \right) \\
 &= \log \left( 1 + \frac{1}{\rho(\mathbf{P}_{12}^T) - 1} \right) ; \\
 &= D_{12}
 \end{aligned}$$

and a simple power constraint is imposed upon the transmit powers.

70. (currently amended) A method as in claim ~~60~~ 69, wherein the optimization is performed in alternating directions and repeated.

71. (currently amended) A method as in claim ~~60-61~~, wherein each node presumes the post-beamforming interference energy remains constant for the adjustment interval and so solves ~~EQ. 3~~

$$\begin{aligned}
 &\min_{\pi_1(q)} \sum_q \pi_1(q) = \mathbf{1}^T \boldsymbol{\pi}_1 \quad \text{subject to the constraint of} \\
 &\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)
 \end{aligned}$$

using classic water filling arguments based on Lagrange multipliers, and then uses a similar equation for the reciprocal element of the link.

1074

1075 72. (currently amended) A method as in claim 60 61, wherein at each node the  
 1076 constrained optimization problem stated in ~~EQ. 13 and 14~~

$$\begin{aligned} & \max_m \sum_{q \in Q(m)} \log(1 + \gamma(q)), \text{ such that} \\ & \frac{\sum_{q \in Q(m)} \pi_1(q) \leq R_1(m), \gamma(q) \geq 0}{\sum_{q \in Q(m)} \pi_1(q) \leq R_1(m), \gamma(q) \geq 0} \end{aligned}$$

1079 is solved using the approximation in ~~EQ. 11~~,

$$\gamma(q) = \frac{P_{21}(q, q) \pi_1(q)}{i_2(q)}$$

1081 and the network further comprises at least one high-level network controller that controls  
 1082 the power constraints  ~~$R_1(q)$~~   $R_1(m)$ , and drives the network towards a max-min  
 1083 solution.

1084

1085

1086 73. (currently amended) A method as in claim 60 61, wherein each node:

1087 is given an initial  $\gamma_0$ ;

1088 generates the model expressed in ~~EQ. 20, EQ. 21, and EQ. 22~~

$$L(\gamma, \mathbf{g}, \beta) = \mathbf{g}^T \gamma, \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

$$\mathbf{g} = \nabla_{\gamma} f(\gamma_0) ;$$

1091 updates the new  $\gamma_{\alpha}$  from ~~EQ. 23 and EQ. 24~~

$$\gamma_* = \arg \min_{\gamma} L(\gamma, \mathbf{g}, \beta), \gamma_{\alpha} = \gamma_0 + \alpha(\gamma_* - \gamma_0) ;$$

1093 determines a target SINR to adapt to; and,

1094 updates the transmit power for each link  $q$  according to ~~EQ. 25 and EQ. 26~~

$$\pi_2(q) = \gamma_{\alpha} i_1(q) / |h(q)|^2$$



$$\pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2$$

1097

1098 74. (currently amended) A method as in claim 60 61, for each node wherein the  
1099 transmit power relationship of ~~EQ. 25 and EQ. 26~~

$$\pi_2(q) = \gamma_\alpha i_1(q) / |h(q)|^2$$

$$\pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2$$

1102 is not known, that:

1103 uses a suitably long block of  $N$  samples is used to establish the relationship, where  
1104  $N$  is either 4 times the number of antennae or 128, whichever is larger;  
1105 uses the result to update the receive weights at each end of the link;  
1106 optimizes the local model as in ~~EQ. 23 and EQ. 24~~

$$\gamma_* = \arg \min_{\gamma} L(\gamma, \mathbf{g}, \beta)$$

$$\gamma_\alpha = \gamma_0 + \alpha(\gamma_* - \gamma_0);$$

1109 and then applies

$$\pi_2(q) = \gamma_\alpha i_1(q) / |h(q)|^2$$

$$\pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2 \quad \text{EQ. 25 and EQ. 26.}$$

1112

1113 75. (currently amended) A method as in claim 60 61 that, for an aggregate proper  
1114 subset  $m$ :

1115 for each node within the set  $m$ , inherits the network objective function model  
1116 given in ~~EQ. 28, EQ. 29, and EQ. 30~~

$$L_m(\gamma, \mathbf{g}, \beta) = \sum_{q \in Q(m)} \mathbf{g}_q \gamma(q)$$

$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

1119 
$$g(q) = i_1(q)i_2(q)/|h(q)|^2 ;$$

1120 eliminates ~~the~~ a step of matrix channel estimation, transmitting instead  
 1121 from that node as a single real number for each link to the other end of  
 1122 said link an estimate of the post beamforming interference power;  
 1123 and ,  
 1124 receives back for each link a single real number being the transmit power.

1125

1126 76. (original) A method as in claim ~~75~~ 74 , that for each pair of nodes assigns to the one  
 1127 presently possessing the most processing capability the power management  
 1128 computations.

1129

1130

1131 77. (currently amended) A method as in claim ~~74~~ 75 that estimates the transfer gains  
 1132 and the post beamforming interference power using simple least squares estimation  
 1133 techniques.

1134

1135

1136 78. (currently amended) A method as in claim ~~74~~ 75 that, for estimating the transfer  
 1137 gains and post beamforming interference power:

1138

1139 instead solves for the transfer gain h using ~~EQ. 31~~

1140 
$$y(n) = hgs(n) + \varepsilon(n);$$

1141 uses a block of N samples of data to estimate h using ~~EQ. 32~~

1142 
$$h = \frac{\sum_{n=1}^N s^*(n)y(n)}{\sum_{n=1}^N |s(n)|^2 g} ;$$

1143 obtains an estimation of residual interference power  ~~$R_e$~~   $R_\varepsilon$  using ~~EQ. 33~~

$$R_{\varepsilon} = \left\langle \left| \varepsilon(n) \right|^2 \right\rangle$$

$$= \frac{1}{N} \sum_{n=1}^N \left( \left| y(n) \right|^2 - \left| ghs(n) \right|^2 \right)$$

and,

obtains knowledge of the transmitted data symbols  $S(n)$  from using remodulated symbols at the output of the codec.

79. (currently amended) A method as in claim ~~77~~ 78 wherein, instead of obtaining knowledge of the transmitted data symbols  $S(n)$  from using remodulated symbols at the output of the codec, the node uses the output of a property restoral algorithm used in a blind beamforming algorithm.

80. (currently amended) A method as in claim ~~77~~ 78 wherein, instead of obtaining knowledge of the transmitted data symbols  $S(n)$  from using remodulated symbols at the output of the codec, the node uses a training sequence explicitly transmitted to train beamforming weights and asset the power management algorithms.

81. (currently amended) A method as in claim ~~77~~ 78 wherein, instead of obtaining knowledge of the transmitted data symbols  $S(n)$  from using remodulated symbols at the output of the codec, the node uses any combination of:

the output of a property restoral algorithm used in a blind beamforming algorithm;  
a training sequence explicitly transmitted to train beamforming weights and asset the power management algorithms;

or,

1169 other means known to the art.

1170

1171

1172 82. (currently amended) A method as in claim ~~60~~ 61, wherein each node  
1173 incorporates a link level optimizer and a decision algorithm, ~~as illustrated in Figure~~  
1174 ~~32A and 32B~~.

1175

1176 83. (currently amended) A method as in claim ~~81~~ 82, wherein the decision  
1177 algorithm is a Lagrange multiplier technique.

1178

1179

1180 84. (currently amended) A method as in claim ~~60~~ 61, wherein the solution to ~~EQ. 3~~

1181  $\min_{\pi_1(q)} \sum_q \pi_1(q) = \mathbf{1}^T \boldsymbol{\pi}_1$  is implemented by a penalty function technique.

1182

1183

1184 85. (currently amended) A method as in claim ~~83~~ 84, wherein the penalty function  
1185 technique:

1186 takes the derivative of  ~~$\gamma(q)$~~   $\gamma(q)$  with respect to  $\boldsymbol{\pi}_1$ ;

1187 and,

1188 uses the Kronecker-Delta function and the weighted background noise.

1189

1190

1191 86. (currently amended) A method as in claim ~~83~~ 84, wherein the penalty function  
1192 technique neglects the noise term.

1193

1194

1195 87. (currently amended) A method as in claim ~~83~~ 84, wherein the penalty function  
1196 technique normalizes the noise term to one.

1197

1198

1199 88. (currently amended) A method as in claim ~~60~~ 61, wherein the approximation  
1200 uses the receive weights.

1201

1202

1203 89. (currently amended) A method as in claim ~~60~~ 61, wherein adaptation to the  
1204 target objective is performed in a series of measured and quantized descent and ascent  
1205 steps.

1206

1207 90. (currently amended) A method as in claim ~~60~~ 61, wherein the adaptation to the  
1208 target objective is performed in response to information stating the vector of change.

1209

1210

1211 91. (currently amended) A method as in claim ~~60~~ 61, which uses the log linear mode  
1212 ~~in EQ. 34~~

1213

$$\beta_q \approx \log \left( \frac{a \pi_1(q) + a_0}{b \pi_1(q) + b_0} \right) = \hat{\beta}_q(\pi_1(q))$$

---

1214 and the inequality characterization ~~in EQ. 35~~  $\hat{\beta}_q(\pi_1(q)) \geq \beta$  to solve the  
1215 approximation problem with a simple low dimensional linear program.

1216

1217

1218 92. (currently amended) A method as in claim ~~60~~ 61, develops the local mode by  
1219 matching function values and gradients between the current model and the actual  
1220 function.

1221

1222

1223 93. (currently amended) A method as in claim ~~60~~ 61, which develops the model as a  
1224 solution to the least squares fit, evaluated over several points.

1225

1226

1227 94. (currently amended) A method as in claim ~~60~~ 61, which reduces the cross-  
1228 coupling effect by allowing only a subset of links to update at any one particular time,  
1229 wherein the subset members are chosen as those which are more likely to be isolated  
1230 from one another.

1231

1232

1233

1234 95. (currently amended) A method as in claim ~~60~~ 61, wherein:  
1235 the network further comprises a network controller element;  
1236 said network controller element governs a subset of the network;  
1237 said network controller element initiates, monitors, and changes the target  
1238 objective for that subset;  
1239 said network controller communicates the target objective to each node in that  
1240 subset;  
1241 and,  
1242 receives information from each node concerning the adaptation necessary to meet  
1243 said target objective.

1244

1245

1246 96. (currently amended) A method as in claim 94 95, wherein said network further  
1247 records the scalar and history of the increments and decrements ordered by the network  
1248 controller.

1249

1250

1251 97. (currently amended) A method as in claim ~~60~~ 61, wherein for any subset, a target  
1252 objective may be a power constraint.

1253

1254

1255 98. (currently amended) A method as in claim ~~60~~ 61, wherein for any subset, a target  
1256 objective may be a capacity maximization subject to a power constraint.

1257

1258

1259 99. (currently amended) A method as in claim ~~60~~ 61, wherein for any subset, a  
1260 target objective may be a power minimization subject to the capacity attainment to the  
1261 limit possible over the entire network.

1262

1263

1264 100. (currently amended) A method as in claim ~~60~~ 61, wherein for any subset, a  
1265 target objective may be a power minimization at each particular node in the network  
1266 subject to the capacity constraint at that particular node.

1267

1268

1269 101. (currently amended) A wireless electromagnetic communications network,  
1270 comprising:

1271 a wireless electromagnetic communications network, comprising

1272 a set of nodes, said set further comprising,

1273 at least a first subset wherein each node is MIMO-capable,

1274 comprising:

1275 a spatially diverse antennae array of M antennae, where M

1276  $\geq$  one,

1277 a transceiver for each antenna in said array,

1278 means for digital signal processing,

1279 means for coding and decoding data and symbols,

1280 means for diversity transmission and reception,

1281 and,

1282 means for input and output from and to a non-radio

1283 interface;

1284 said set of nodes further comprising one or more proper subsets of nodes,

1285 being at least one transmitting and at least one receiving subset, with said

1286 transmitting and receiving subsets having a topological arrangement

1287 whereby:

1288 each node in a transmitting subset has no more nodes with which it  
 1289 will simultaneously communicate in its field of view, than it has  
 1290 number of antennae;  
 1291 each node in a receiving subset has no more nodes with which it  
 1292 will simultaneously communicate in its field of view, than it can  
 1293 steer independent nulls to;  
 1294 and,  
 1295 each member of a non-proper subset cannot communicate with any  
 1296 other member of its non-proper subset;  
 1297 transmitting independent information from each node in a first non-proper subset  
 1298 to one or more receiving nodes belonging to a second non-proper subset that are  
 1299 viewable from the transmitting node;  
 1300 processing independently information transmitted to a receiving node in a second  
 1301 non-proper subset from one or more nodes in a first non-proper subset is  
 1302 independently by the receiving node;  
 1303 and,  
 1304 optimizing the network by dynamically adapting the ~~diversity channels~~ means for  
 1305 diversity transmission and reception between nodes of said transmitting and receiving  
 1306 subsets.  
 1307  
 1308  
 1309 102. (currently amended) An apparatus as in claim ~~400~~ 101, further  
 1310 comprising an element for scheduling according to a Demand-Assigned, Multiple-Access  
 1311 algorithm.  
 1312  
 1313  
 1314 103. (currently amended) An apparatus as in claim ~~400~~ 101, further comprising for  
 1315 each node in said first subset a LEGO adaptation element.  
 1316  
 1317  
 1318 104. (currently amended) An apparatus as in claim ~~400~~ 101, further comprising:



for each node in said first subset a LEGO adaptation element; and,  
one or more network controllers.

105. (currently amended) A method as in claim 1, wherein the step of dynamically adapting the diversity ~~channels~~ capability means and said proper subsets to optimize said network further comprises:

matching each transceiver's degrees of freedom (DOF) to the nodes in the possible link directions;  
equalizing those links to provide node-equivalent uplink and downlink capacity.

106. (original) A method as in claim 105, further comprising, after the DOF matching:  
assigning asymmetric transceivers to reflect desired capacity weighting;  
adapting the receive weights to form a solution for multipath resolutions;  
employing data and interference whitening as appropriate to the local conditions;  
and,  
using retrodirective transmission gains during subsequent transmission operations.

107. (original) A method as in claim 105, wherein the receive weights are ~~similarly-~~  
~~modified~~ matched to the nodes in the possible link directions.

108. (currently amended) A method for optimizing a wireless electromagnetic communications network, comprising:

a wireless electromagnetic communications network, comprising

a set of nodes, said set of nodes further comprising,

at least a first subset wherein each node is MIMO-capable,

comprising:

an antennae array of  $M$   $M$  antennae, where  $M$   $M$   $\geq$  one,

1350 a transceiver for each antenna in said spatially diverse  
1351 antennae array,  
1352 means for digital signal processing to convert analog radio  
1353 signals into digital signals and digital signals into analog  
1354 radio signals,  
1355 means for coding and decoding data, symbols, and control  
1356 information into and from digital signals,  
1357 diversity capability means for transmission and reception of  
1358 said analog radio ~~waves~~ signals;  
1359 and,  
1360 means for input and output from and to a non-radio  
1361 interface for digital signals;  
1362 said set of nodes being deployed according to design rules that prefer  
1363 meeting the following criteria:  
1364  
1365 said set of nodes further comprising two or more proper subsets of  
1366 nodes, with a first proper subset being the transmit uplink / receive  
1367 downlink set, and a second proper subset being the transmit  
1368 downlink / receive uplink set;  
1369  
1370 each node in said set of nodes belonging to no more transmitting  
1371 uplink or receiving uplink subsets than it has diversity capability  
1372 means;  
1373  
1374 each node in a transmit uplink / receive downlink subset has no  
1375 more nodes with which it will hold time and frequency coincident  
1376 communications in its field of view, than it has diversity capability  
1377 means;  
1378  
1379 each node in a transmit downlink / receive uplink subset has no  
1380 more nodes with which it will hold time and frequency coincident

1381 communications in its field of view, than it has diversity capability  
 1382 means;  
 1383  
 1384 each member of a transmit uplink / receive downlink subset cannot  
 1385 hold time and frequency coincident communications with any  
 1386 other member of that transmit uplink / receive downlink subset;  
 1387 and,  
 1388 each member of a transmit downlink / receive uplink subset cannot  
 1389 hold time and frequency coincident communications with any  
 1390 other member of that transmit downlink / receive uplink subset;  
 1391  
 1392 transmitting, in said wireless electromagnetic communications network,  
 1393 independent information from each node belonging to a first proper subset, to one  
 1394 or more receiving nodes belonging to a second proper subset that are viewable  
 1395 from the transmitting node;  
 1396  
 1397 processing independently, in said wireless electromagnetic communications  
 1398 network, at each receiving node belonging to said second proper subset,  
 1399 information transmitted from one or more nodes belonging to said first proper  
 1400 subset;  
 1401  
 1402 optimizing at the local level for each node for the channel capacity  $\mathcal{D} \underline{D}_{21}$   
 1403 according to ~~EQ. 49~~,

$D_{21} = \max \beta$  such that

$$\beta \leq \sum_{q \in U(m)} \sum_k \log(1 + \gamma(k, q)),$$

$$\gamma(k, q) \geq 0,$$

1404

$$\sum_m R_1(m) \leq R,$$

$$\pi_1(k, q) \geq 0,$$

$$\sum_{q \in U(m)} \sum_k \pi_1(k, q) \leq R_1(m)$$


---

1405

solving first the reverse link power control problem; then treating the forward link  
1406 problem in an identical fashion, substituting the subscripts 2 for 1 in said  
1407 equation;

1408

and,

1409

dynamically adapting the diversity channels capability means and said proper  
1410 subsets to optimize said network.

1411

1412

1413 109. (currently amended) A method as in claim 108, further comprising:

1414

1415 for each aggregate subset  $m$ , attempting to achieve the given capacity objective,  $\beta$

1416  $\beta$ , as described in

$$\min_{\pi_r(q)} \sum_{q \in Q(m)} \pi_r(q), \quad \text{such that}$$


---

$$\beta = \sum_{q \in Q(m)} \log(1 + \gamma(q))$$


---

1419

1420 EQ. 50, by:

(1) optimizing the receive beamformers, using simple MMSE processing, to simultaneously optimize the SINR;

(2) based on the individual measured SINR for each  $q$  index, attempt to incrementally increase or lower its capacity as needed to match the current target; and,

(3) ~~stepping~~ stepping the power by a quantized small step in the appropriate direction;

then,

when all aggregate sets have achieved the current target capacity, then the network can either increase the target capacity  $\beta$ , or add additional users to exploit the now-known excess capacity.

110. (currently amended) A method as in claim ~~106~~ 107, wherein ~~instead of optimizing for channel [capability means] capacity~~, the network optimizes for QoS and not diversity capability means capacity.

111. (currently amended) A method as in claim 94 95, wherein:

said network controller adds, drops, or changes the target capacity for any node in the set the network controller controls.

112. (currently amended) A method as in claim 94 95, wherein:

said network controller may, either in addition to or in replacement for altering  $\beta$ , add, drop, or change channels between nodes, frequencies, coding, security, or protocols, polarizations, or traffic density allocations usable by a particular node or channel.

1450 113. (currently amended) A wireless electromagnetic communications network,  
1451 comprising:  
1452 a set of nodes, said set further comprising,  
1453 at least a first subset wherein each node is MIMO-capable,  
1454 comprising:  
1455 a spatially diverse antennae array of  $M$   $M$  antennae, where  
1456  $M$   $M$   $\geq$  one,  
1457 a transceiver for each antenna in said array,  
1458 ~~13~~ means for digital signal processing,  
1459 ~~14~~ means for coding and decoding data and symbols,  
1460 ~~19~~ means for diversity transmission and reception,  
1461 pilot symbol coding & decoding element  
1462 timing synchronization element  
1463 and,  
1464 means for input and output from and to a non-radio  
1465 interface;  
1466 said set of nodes further comprising two or more proper subsets of nodes,  
1467 there being at least one transmitting and at least one receiving subset, with  
1468 said transmitting and receiving subsets subset having a diversity  
1469 arrangement whereby:  
1470 each node in a transmitting subset has no more nodes with which it  
1471 will simultaneously communicate in its field of view, than it has  
1472 number of antennae;  
1473 each node in a receiving subset has no more nodes with which it  
1474 will simultaneously communicate in its field of view, than it can  
1475 steer independent nulls to;  
1476 and,  
1477 each member of a non-proper subset cannot communicate with any  
1478 other member of its non-proper subset over identical diversity  
1479 channels;  
1480 a LEGO adaptation element and algorithm;

a network controller element and algorithm;  
 whereby each node in a first non-proper subset transmits independent information  
 to one or more receiving nodes belonging to a second non-proper subset that are  
 viewable from the transmitting node;  
 each receiving node in said second non-proper subset processes independently  
 information transmitted to a from one or more nodes in a first non-proper subset is  
 independently by the receiving node;  
 each node uses means to minimize SINR between nodes transmitting and  
 receiving information;  
 the network is designed such that substantially reciprocal symmetry exists for the  
 uplink and downlink channels by,

if the received interference is spatially white in both link directions, setting

$$\mathbf{g}_1(q) \propto \mathbf{w}_2^*(q) \text{ and } \mathbf{g}_2(q) \propto \mathbf{w}_1^*(q)$$

$$\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q) \text{ and } \mathbf{g}_1(q) \propto \mathbf{w}_1^*(q) \text{ at both ends of the link,}$$

where  $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$  are the linear transmit  
 and receive weights used in the downlink;

but if the received interference is not spatially white in both link  
 directions, constraining  $\{\mathbf{g}_1(q)\}$  and  $\{\mathbf{g}_2(q)\}$

$\{\mathbf{g}_1(q)\}$  and  $\{\mathbf{g}_2(q)\}$  to satisfy:

$$Q_{21}$$

$$\sum_{q=1}^{N_1} \mathbf{g}_1^T(q) \mathbf{R}_{111}[\mathbf{n}_1(q)] \mathbf{g}_1^*(q) =$$

$$q=1$$

$$N_1$$

$$\sum_{n=1}^{M_1} \text{Tr}\{\mathbf{R}_{111}(n)\} = M_1 \mathbf{R}_1;$$

$$n=1$$

1507

1508

 $\Theta_{12}$ 

1509

$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{i_2 i_2} [n_2(q)] \mathbf{g}_2^*(q) =$$

1510

$$\sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{i_2 i_2}(n)\} = M_2 R_2,$$

1511

1512

1513

1514

$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{i_1 i_1} (n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{i_1 i_1}(n)\} = M_1 R_1$$

1516

$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{i_2 i_2} (n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{i_2 i_2}(n)\} = M_2 R_2$$

1517

;

1518

the network uses any standard communications protocol;

1519

and,

1520

the network is optimized by dynamically adapting the means for diversity

1521

transmission and reception diversity channels between nodes of said transmitting

1522

and receiving subsets.

1523

1524

1525 114. (currently amended) A wireless electromagnetic communications network as in

1526

claim 112 113:

1527

wherein each node may further comprise a Butler Mode Forming element, to

1528

enable said node to ratchet the number of active antennae for a particular uplink

1529

or downlink operation up or down.

1530

1531



1532 115. (currently amended) A wireless electromagnetic communications network as in  
1533 claim ~~50~~ 101:  
1534 incorporating a dynamics-resistant multitone element.  
1535  
1536  
1537 116. (original) The use of a method as described in claim 1 for fixed wireless  
1538 electromagnetic communications.  
1539  
1540 117. (currently amended) The use of an apparatus as described in claim ~~50~~ 101 for  
1541 fixed wireless electromagnetic communications.  
1542  
1543 118. (original) The use of a method as described in claim 1 for mobile wireless  
1544 electromagnetic communications.  
1545  
1546 119. (currently amended) The use of an apparatus as described in claim ~~50~~ 101 for  
1547 mobile wireless electromagnetic communications.  
1548  
1549 120. (original) The use of a method as described in claim 1 for mapping operations using  
1550 wireless electromagnetic communications.  
1551  
1552 121. (currently amended) The use of an apparatus as described in claim ~~50~~ 101 for  
1553 mapping operations using wireless electromagnetic communications.  
1554  
1555 122. (original) The use of a method as described in claim 1 for a military wireless  
1556 electromagnetic communications network.  
1557  
1558 123. (currently amended) The use of an apparatus as described in claim ~~50~~ 101 for a  
1559 military wireless electromagnetic communications network.  
1560  
1561 124. (original) The use of a method as described in claim 1 for a military wireless  
1562 electromagnetic communications network for battlefield operations.

1563

1564 125. (currently amended) The use of an apparatus as described in claim ~~50~~ 101 for a  
1565 military wireless electromagnetic communications network for battlefield operations.

1566

1567 126. (original) The use of a method as described in claim 1 for a military wireless  
1568 electromagnetic communications network for Back Edge of Battle Area (BEBA)  
1569 operations.

1570

1571 127. (original) The use of an apparatus as described in claim ~~50~~ 101 for a military  
1572 wireless electromagnetic communications network for Back Edge of Battle Area (BEBA)  
1573 operations..

1574

1575 128. (original) The use of a method as described in claim 1 for a wireless electromagnetic  
1576 communications network for intruder detection operations.

1577

1578 129. (original) The use of an apparatus as described in claim ~~50~~ 101 for a wireless  
1579 electromagnetic communications network for intruder detection operations.

1580

1581 130. (original) The use of a method as described in claim 1 for a wireless electromagnetic  
1582 communications network for logistical intercommunications.

1583

1584 131. (original) The use of an apparatus as described in claim ~~50~~ 101 for a wireless  
1585 electromagnetic communications network for logistical intercommunications.

1586

1587 132. (original) The use of a method as described in claim 1 in a wireless electromagnetic  
1588 communications network for self-filtering spoofing signals.

1589

1590 133. (original) The use of an apparatus as described in claim ~~50~~ 101 for a wireless  
1591 electromagnetic communications network for self-filtering spoofing signals.

1592

1593 134. (original) The use of a method as described in claim 1 in a wireless  
1594 electromagnetic communications network for airborne relay over the horizon.  
1595  
1596 135. (original) The use of an apparatus as described in claim ~~50~~ 101 for a wireless  
1597 electromagnetic communications network for airborne relay over the horizon.  
1598  
1599 136. (original) The use of a method as described in claim 1 in a wireless electromagnetic  
1600 communications network for traffic control.  
1601  
1602 137. (currently amended) The use of a method as in claim ~~166~~ 1, further comprising  
1603 the use thereof for air traffic control.  
1604  
1605 138. (currently amended) The use of a method as in claim ~~166~~ 1, further comprising  
1606 the use thereof for ground traffic control.  
1607  
1608 139. (currently amended) The use of a method as in claim ~~166~~ 1, further comprising  
1609 the use thereof for a mixture of ground and air traffic control.  
1610  
1611 140. (original) The use of an apparatus as described in claim ~~50~~ 101 for a wireless  
1612 electromagnetic communications network for traffic control.  
1613  
1614 141. (currently amended) The use of an apparatus as in claim ~~170~~ 101, further  
1615 comprising the use thereof for air traffic control  
1616  
1617 142. (currently amended) The use of an apparatus as in claim ~~170~~ 101, further  
1618 comprising the use thereof for ground traffic control.  
1619  
1620 143. (currently amended) The use of an apparatus as in claim ~~170~~ 101, further  
1621 comprising the use thereof for a mixture of ground and air traffic control.  
1622

1623 144. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1624 communications network for emergency services.  
1625  
1626 145. (original) The use of an apparatus as in claim ~~50~~ 101 in a wireless electromagnetic  
1627 communications network for emergency services.  
1628  
1629 146. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1630 communications network for shared emergency communications without interference.  
1631  
1632 147. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a wireless  
1633 electromagnetic communications network for shared emergency communications without  
1634 interference.  
1635  
1636 148. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1637 communications network for positioning operations without interference.  
1638  
1639 149. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a wireless  
1640 electromagnetic communications network for positioning operations without interference.  
1641  
1642 150. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1643 communications network for high reliability networks requiring graceful degradation  
1644 despite environmental conditions or changes..  
1645  
1646 151. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a wireless  
1647 electromagnetic communications network for high reliability networks requiring graceful  
1648 degradation despite environmental conditions or changes..  
1649  
1650 152. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1651 communications network for a secure network requiring assurance against unauthorized  
1652 intrusion.  
1653

1654 153. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1655 communications network for a secure network requiring message end-point assurance.  
1656

1657 154. (original) The use of a method as in claim 1 in a wireless electromagnetic  
1658 communications network for a secure network requiring assurance against unauthorized  
1659 intrusion and message end-point assurance.  
1660

1661 155. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a wireless  
1662 electromagnetic communications network for a secure network requiring assurance  
1663 against unauthorized intrusion.  
1664

1665 156. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a wireless  
1666 electromagnetic communications network for a secure network requiring message end-  
1667 point assurance.  
1668

1669 157. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a wireless  
1670 electromagnetic communications network for a secure network requiring assurance  
1671 against unauthorized intrusion and message end-point assurance.  
1672

1673

1674 158. (original) The use of a method as in claim 1 in a cellular mobile radio service.  
1675

1676 159. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a cellular  
1677 mobile radio service.  
1678

1679 160. (original) The use of a method as in claim 1 in a personal communication service.  
1680

1681 161. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a personal  
1682 communication service.  
1683

1684 162. (original) The use of a method as in claim 1 in a private mobile radio service.

1685

1686 163. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a private  
1687 mobile radio service.

1688

1689 164. (original) The use of a method as in claim 1 in a wireless LAN.

1690

1691 165. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a wireless LAN.

1692

1693 166. (original) The use of a method as in claim 1 in a fixed wireless access service.

1694

1695 167. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a fixed wireless  
1696 access service.

1697

1698 168. (original) The use of a method as in claim 1 in a broadband wireless access service.

1699

1700 169. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a broadband  
1701 wireless access service.

1702

1703 170. (original) The use of a method as in claim 1 in a municipal area network.

1704

1705 171. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a municipal area  
1706 network.

1707

1708 172. (original) The use of a method as in claim 1 in a wide area network.

1709

1710 173. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in a wide area  
1711 network.

1712

1713 174. (original) The use of a method as in claim 1 in wireless backhaul.

1714

1715 175. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in wireless  
1716 backhaul.  
1717  
1718 176. (original) The use of a method as in claim 1 in wireless backhaul.  
1719  
1720 177. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in wireless  
1721 backhaul.  
1722  
1723 178. (original) The use of a method as in claim 1 in wireless SONET.  
1724  
1725 179. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in wireless SONET.  
1726  
1727 180-181. (Cancelled)  
1728  
1729 182. (original) The use of a method as in claim 1 in wireless Telematics.  
1730  
1731 183. (currently amended) The use of an apparatus as in claim ~~50~~ 101 in wireless  
1732 Telematics.  
1733